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MINERAL SALT REQUIREMENT OF RICE[1]

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One of the most important problems in connection with rice culture is the determination of ways by which an increase in yield of crop may be obtained. In the Philippines an increase in the production of this staple crop may be accomplished by the application of fertilizer materials. For the rice soils in this country are fast becoming depleted of essential food elements; our system of rice farming is wasteful. Fertilizer materials cannot be applied with much intelligence from the scientific point of view as the mineral requirements of rice are not well known. Hence, the problem requires our most earnest attention.

In the study of the mineral nutrition of rice, several methods may be employed in determining, (1) the right kinds of fertilizer ingredients to use, (2) the proper amounts to use, and (3) the proper combinations or proportions of the fertilizer materials to supply to the plant.

One of the best indications of the right kind, right amount, and the right proportions of the fertilizer ingredients to use is the information we obtain after analyzing the different parts of the body of the plant. Likewise, analyses of the soils that grow rice well may bring out data that will be of great value. The results of those analyses should give us at least an approximately correct proportion and amount of K, N, and P used by this plant during its life time. The data from the chemical analyses of the soils and of the plant itself are, however, not always reliable. They should be used in a guarded manner; their principal value is in making preliminary studies on the mineral needs of the plant.

Another method that should be used, whenever possible, is the growing of the plant in solution cultures of different concentrations. Those cultures should contain all the elements essential to the growth and development of higher plants and should be mixed in different proportions. The hit-or-miss way of studying the mineral nutrition of plants is being rapidly replaced with a method, systematic and schematic (1). By this method, the results obtained are relatively easy to explain. It involves the use of three or four salts or fertilizers. The principal ingredients of these are mixed in different proportions. Several concentrations may be tried. From the trials one or two culture solutions are usually discovered

[1] Read at the semi-annual meeting of the Philippine Society of Technical Agriculturists held in College of Agriculture on August 28, 1921. Certain parts of this paper were taken from the writer's article on rice that appeared in the **Philippine Journal of Science 16:** (No. 5) 1920. Experiment Station contribution, No. 70.

that give the right clue as to the proportions of the essential elements, such as the K, N, and P, that give the best growth or the highest yield of rice. This method is resorted to only to establish principles regarding the nutrition requirements of this plant.

A third method of determining the kind, amount, and combination of nutriments to apply, is the application of fertilizers in the soil. The amount to use should be guided by the principles established from culture solution experiments and by the data obtained from the analyses of rice soils and of the body of the plant itself. If this important information is not available then we can carry out directly experiments in pots or in plots applying different proportions of the K, N, and P contents of the fertilizers to be used. This initial study should never involve extensive cultures because it may result in useless expenditure of time and money on the part of the investigator. A few pot or plot cultures will answer the purpose. From the results of these pot or plot experiments, cultures on a large scale may follow without running any special risk so far as fertilization is concerned.

A fourth method by which we can increase the yield of rice is with the use of some chemical stimulants. This phase of the problem should be the last one to be resorted to as our knowledge on this subject is very limited.

With this rather brief description of the methods usually employed in the determination of the mineral salt requirements of the rice plant, I shall now attempt to review some of the most important papers, published or awaiting publication, bearing on mineral nutrition of rice plant,—especially in relation to nitrogen-bearing salts.

The problem of the mineral nutrition of rice brings up the question of ammonium salts as possible sources of nitrogen. Several studies have been carried out but they were mostly on the relation of nitrogen-bearing fertilizers of the plant. Literature points out that the rice plant is benefited by an application of any of the ammonium salts. But modern investigators (2) have found that it is possible to grow wheat and other higher plants in culture solution containing, besides a trace of iron phosphate, three salts,—monopotassium phosphate, calcium nitrate, and magnesium sulphate. I decided to try this simpler scheme. Using the same salts and following the Schreiner and Skinner triangular scheme (3), I tried to grow rice in culture solutions of different concentrations and with different proportions of those three salts. I found that the rice could not be grown successfully in any of them. Following, then, the suggestion in the literature on the subject (4) I added ammonium sulphate to the culture solutions, making my solutions a four-salt type instead of the three-salt type. In some of the four-salt solutions tried, excellent growth of young rice plants was obtained. This result suggests that this plant requires the ammonium ion.

The question then arose whether the presence of the nitrate ion in the medium might not be unnecessary or even positively harmful to the young rice plant; so the third stage of my studies dealt with still another four-salt type solution, which contained all the generally necessary mineral elements but contained no nitrate. Nitrogen was supplied only as ammonium sulphate. This type of solution was also tested with many different sets of salt proportions and with a number of different total concentrations. The results showed that some of these solutions gave very good growth, but the best of them were not so good as

the best ones containing nitrate; this type of solution always produced a characteristic leaf injury. For the range of total concentrations tried, 0.08 to 0.2 atmosphere or total concentrations of 0.0016 to 0.0038 gram-molecule per liter (of all salts taken together), the best solutions, containing both the ammonium ion and the nitrate ion, were characterized by having a very high relative molecular partial concentration of magnesium sulphate. They generally had comparatively low relative molecular partial concentrations of monopotassium phosphate and calcium nitrate. It may be stated that the most promising solution for this plant has about 0.002 gram-molecule per liter (of all salts), the salts being present in about the following molecular proportions:

$KH_2PO_4 : (NH_4)_2SO_4 : Ca(NO_3)_2 : MgSO_4 = 1 : 1\frac{1}{2} : 1\frac{1}{2} : 4.$

It is safe to say that one very excellent solution would have the potassium, ammonium and calcium salts in the same proportions, while the molecular partial concentration of the magnesium salt should be four or five times as great as that of any one of the others. The tolerance of this plant for magnesium sulphate is especially remarkable. The foregoing study has so far been the only one carried out in culture solutions in a systematic way; other studies have been carried out in pot, plot, and field cultures and, as already mentioned, in a rather hit-or-miss way.

Kellner (5) conducted perhaps the first solution-culture experiments on lowland rice, with the aim of determining whether this plant thrives best with one or another form of nitrogen-bearing salts. He grew his plants in nutrient solutions supplying all the essential chemical elements for normal growth of ordinary higher plants. In one solution, nitrogen was supplied as potassium nitrate, and in another as ammonium sulphate, and his experiments were repeated several times, using the same salts but varying the amounts. He concluded that paddy rice in the early stages of its development grew better in the nutrient medium supplied with ammoniacal nitrogen than in the one supplied with nitrate nitrogen, while during the later stages of development the nitrate proved to be a better source of nitrogen than the ammonium salt. He also tried culture solutions containing the other essential elements and having the ammonium salt and the nitrate both present at once, and found that the combination of these forms of nitrogen gave better growth than did either form alone.

The beneficial effect of ammonium sulphate, as well as the unsuitability of nitrates as sources of nitrogen for rice, were also observed by Nagaoka (6), who carried out a series of rather extensive pot and plot experiments with upland and lowland varieties of rice grown to maturity. He began his cultures with plants about 42 days old, so that the plants had passed beyond the first stages of growth before they were tested. By means of pot cultures with soil, he compared the growth and the yield of a lowland rice supplied with different amounts of ammonium sulphate with those of the same variety supplied, separately, with one of the salts: sodium nitrate, potassium nitrate, calcium nitrate, barium nitrate, strontium nitrate, and magnesium nitrate. He found that plants grown in the media supplying nitrogen in the form of ammonium sulphate alone were green and produced much tillering (branching at the base of the stem), while plants "fed" with one of the nitrates were yellowish and produced but little tillering. The six nitrates tested were about alike in this effect. Nagaoka observed, however, that the seed ripened ten days earlier when the plants had

been supplied with a nitrate than when they had been supplied with the ammonium salt.

The field-plot experiments of Nagaoka were planned to study the fertilizer values of sodium nitrate and ammonium sulphate. In these experiments he applied one or the other of the two salts to the soil. The fertilizer application was made before planting and also at intervals during the growth of the plants. Lowland rice was again used and, as in his previous pot experiments, the yield obtained showed that ammonium sulphate was about two and one-half times as good as sodium nitrate in this respect.

In another set of pot experiments, with upland as well as lowland rice, Nagaoka used a soil to which a fertilizer without nitrogen was similarly applied in all cases. To the pot of one group he added different amounts of sodium nitrate, and to those of another group he added different amounts of ammonium sulphate. Some of the pots of each treatment were kept wet as in rice paddies, while in other pots the soil was kept merely moist. The results obtained showed that ammonium sulphate gave better yields than the sodium nitrate, for both forms of rice and for both soil-moisture conditions. The ammonium salt was always absorbed to a greater extent than was the nitrate, but the upland variety absorbed more sodium nitrate than did the lowland variety. As to the moisture content of the soil, both varieties gave good yields in each of the two moisture conditions studied, but the results were better with lowland rice in wet soil and with upland rice in soil merely moist.

In the researches of Vibar (7) of the College of Agriculture in 1920 with two varieties of rice, he observed also the superiority of ammonium sulphate to sodium nitrate. He found that ammonium sulphate was effective in increasing the yield of straw and of grain of the Caviteño variety of rice (lowland) and the Tiniaong variety (upland). Sodium nitrate was found toxic to the lowland variety, but somewhat beneficial to the upland variety when applied singly or in combination with other fertilizers.

The apparent failure of the rice plant to utilize nitric nitrogen and its apparent preference for the ammoniacal form were ascribed by Nagaoka to the fact that paddy rice does "not accumulate a sufficient quantity of sugar in the leaves to convert all the nitric acid absorbed into protein". The chlorotic appearance of the plants supplied with nitrogen solely as nitrates might be "due to physiological influence of accumulated nitrate". Nagaoka pointed out that the soil of the pot receiving large additions of nitrate gave a slight nitrite reaction, and he suggested that denitrification (resulting in the formation of nitrites from nitrates in the soil) might take place in the rice paddy through the action of micro-organism, so that the excessive amount of nitrites thus formed might poison the plants.

Daikuhara (8) also found that the application of certain ammonium compounds to the soil was beneficial to the rice. He used sand cultures to which limestone and magnesium sulphate were added in various proportions. He also added sodium nitrate to one pot and ammonium sulphate to another. To a third pot ammonium nitrate was added. The total yield (grain and straw) showed that under the conditions of the experiments, ammonium sulphate was about two and one-half times as beneficial as was sodium nitrate, thus confirming the general conclusions of Nagaoka. Daikuhara found also that the fertilizer

value of ammonium nitrate was intermediate between the values of ammonium sulphate and sodium nitrate.

Aso and Bahadur (9) found that the combination of ammonium sulphate and disodium phosphate produced better results with paddy rice in the field than the combinations of any other salts in their tests.

Krauss (10) also reports results from pot and field experiments with rice, indicating that (of the different nitrogenous fertilizers that he tested) ammonium sulphate ranked above calcium nitrate and sodium nitrate by the criterion of yield of grain.

The superior fertilizer value for the rice plant of ammonium sulphate, as compared with the values of sodium nitrate, calcium nitrate, magnesium nitrate, and ammonium nitrate, was also noted by Kelley (11). He employed lowland rice in both field and pot cultures, adding nitrogenous fertilizers before planting and, in other cases, at intervals during the culture period. The cultures supplied with ammonium sulphate showed good growth and good yields of both straw and grain, while those in which nitrogen was supplied to the soil only as sodium nitrate gave but low yields. Apparently this nitrate was ineffective as a fertilizer. He also found that the ammonium salt applied before planting proved more beneficial than did the same salt applied at intervals during the culture period. In pot cultures the addition of nitrate to the soil proved beneficial in the latter part of the growth period, from near the flowering stage to maturity. Kelley suggested that this difference in the response of the rice plant to soil fertilization with sodium nitrate and with ammonium sulphate, might be due to the fact that the lowland rice plant "has in a large measure lost the power of reducing nitrates," which, in turn, might be due to the fact that this plant has been "grown for centuries under conditions that largely exclude the formation of nitrates". While these considerations may be of interest in connection with genetics and phylogeny, still there are physiological reasons for the observed state of affairs (which may be sought in the plant itself) that remain untouched. From the standpoint of genetics it might be asked whether the paddy rice plant ever had the power of reducing the nitrates. Kelley appreciated the unsatisfactory status of the problem, however, and ended his discussion by emphasizing the need for much more study along these lines; he said that "further experiments will be conducted to determine the correctness of this view" but this promise apparently has not yet been fulfilled.

Similar beneficial effects of ammonium sulphate upon rice plants were observed by Daikuhara and Imaseki (12) with pot cultures. They found that ammonium sulphate alone was superior to sodium nitrate alone and also to a combination of these two salts.

From field experiments W. H. Harrison (13) concluded that nitrates were unsuitable for rice, but the ammonium compounds, or manures that yield ammonia under anaerobic conditions of fermentation, were of great value. J. B. Harrison (14), on the other hand, reports that the application of ammonium sulphate to field plots of rice resulted in a decreased yield. This lower yield, however, was thought to be due to lodging, which occurred on account of the very luxuriant growth which took place in the plots supplied with ammonium sulphate, rather than to any directly unjurious effect of the salt.

Further experimental evidence in favor of the idea that ammonium salts are good sources of nitrogen for rice is available from later work by Kelley (15), who conducted a series of field trials. Ammonium sulphate was added to one plot and sodium nitrate to another, the addition being made before the time of planting. To the soils of other plots nitrogenous fertilizers were added from time to time during the development of the plants. The results agreed in indicating the superiority of ammonium sulphate over sodium nitrate. Kelley concluded that—

> a complete fertilizer proved no more effective than ammonium sulphate alone, whereas the application of both ammonium sulphate and potassium sulphate caused a decrease as compared with that obtained from ammonium sulphate alone.

At this College Trelease and Jurado (16) also observed that the yield of straw and grain was positively correlated with the amount of ammonium sulphate added to soil. Comparing the merit of ammonium sulphate as a fertilizer for rice with that of calcium phosphate or potassium sulphate, they found that the concentration of either of the latter two salts had no relation to yield of grain and straw. This finding corroborates that of Trelease (17) in his cultures using the same kinds of salts.

Again, at this College, Trelease and Paulino (18) ran cultures of three-salt type. In these cultures they used mono-calcium phosphate, potassium sulphate and any one of the nitrogen-bearing salts, ammonium sulphate, ammonium nitrate, calcium nitrate, and sodium nitrate. In those cultures rice plant was grown. They found no correlation between the yield of grain and straw and the amount of either the mono-calcium phosphate or potassium sulphate, but marked correlation was observed between the total yield and the amount of any of the nitrogenous fertilizers used. The highest yield was obtained with ammonium sulphate and in a descending order fairly good results were obtained when ammonium nitrate, calcium nitrate or sodium nitrate was employed. These results further show the superiority of ammonium sulphate over any other nitrogenous fertilizer when used in combination with other essential elements bearing salts.

From the foregoing review of the more definite contributions that have been made toward a knowledge of the mineral nutrition of rice, it appears that there is good foundation for the suppositions that:

(1) This plant requires the same chemical elements as do other higher plants.

(2) The young plants are not suited to deriving their nitrogen from nitrates but thrive very well when ammonium sulphate (or probably other ammonium salt) is supplied.

(3) The older plants are able to derive their nitrogen supply from nitrates, but may be able to thrive (with the only possible supply of nitrates in the soil) when the ammonium ion is available in a proper quantity.

(4) Tests with culture solutions have shown that the young rice plant thrives best when both the ammonium and the nitrate ions are present in the solutions.

(5) When the ammonium ion was the only source of nitrogen, good growth of the plant was observed in some cultures but even the best of the plants always showed a characteristic leaf injury, a drying of large portions at the tip.

(6) The best cultures are characterized by the presence of about equal amounts of mono-potassium phosphate, calcium nitrate, and ammonium sulphate, but the supply of magnesium sulphate is four to five times as much as any of the other salts. The rice plant seems to be especially tolerant of a heavy supply of this salt.

(7) Ammonium salts are beneficial to both lowland and upland rice, but the latter thrives well in soils or cultures where nitrate is the only source of nitrogen.

(8) A great deal more experimentation will have to be carried out before we can appreciate the value, or the meaning even, of some of the results we have at present.

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(15) Kelley, W. P. Rice soils of Hawaii. Their fertilization and management. Hawaiian Agricultural Experiment Station Bulletin 31. U. S. Department of Agriculture, Washington. 1914.

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A HOST INDEX OF INSECTS INJURIOUS TO PHILIPPINE CROPS: II [1]

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Incidentally with the class room and experimental work of the Department of Entomology, a large number of insects of economic importance are collected. Special effort has so far been made to collect those species seriously affecting economic plants. Since the publication of the first host index,[2] a number of additions have been brought to my attention, and those which have been definitely identified are included in this addition.

Some of these pests deserve special comment either for their importance or unusual occurrence. The notorious Black Scale (*Saissetia oleae* Bern.), so abundant and injurious in California, has been found here on numerous hosts; the reason for its having been previously recorded only from *Gardenia* or *Jasminum*[3] in the Philippines probably being that, although a general feeder, it is so heavily parasitized here that it has been unable to do much more than hold its own, and thus is infrequently met with by the collector. Many new records of hosts in the Philippines for other scale insects are also included here, and should be of interest to quarantine officers since many of them have already proven of vast importance in other countries.

During the year large numbers of the larvae of the Atlas Moth (*Attacus atlas* Linn.) were gathered from the avocado trees on the Campus. Apparently these insects will prove serious pests to the avocado industry, in several cases the trees were practically defoliated before handpicking was undertaken as a control measure.

Among the interesting material obtained from breeding work were the additional host records of fruit flies. As might have been expected, *Dacus ferrugineus* Fabr. was found to breed naturally in the fruit of abaca (*Musa textilis* Nee.) Although apparently unnoticed here before, the Cerambycid (*Dihammus fistulator* Germ.) was found boring in the stems of eggplant (*Solanum melongena* Linn.) and seriously affecting many plants.

During October and November, *Xylotrupes gideon* Linn. was found in great numbers in the *Canavalia* plots on the College Campus. While not ravenous eaters, they did considerable damage to the leaves, stems, and pods. Apparently they were there for breeding purposes, males and females being found in nearly equal numbers, and soon after their arrival, the females began laying eggs in the soil below the plants until, at the present writing, it is almost impossible to turn over a shovel full of earth without disturbing many eggs or young grubs.

A small Galerucid (*Monolepta bifasciata* Hornst.) was found in large numbers feeding on the tender growth of mango trees in Los Baños and on the Campus.

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[1] Experiment Station contribution, No. 71.

[2] Woodworth, H. E. A host index of insects injurious to Philippine crops. **Philippine Agriculturist 10:** 9-35. 1921.

[3] Robinson, Elizabeth. Coccidae of the Philippine Islands. **Philippine Journal of Science, 12 D:** 1-47. 1917.

CANANGIUM ODORATUM (Lam.) Baill. (*Cananga odorata* Hk. f. & Th.) (Ilang-ilang)

DIPTERA

TRYPETIDAE

Dacus ferrugineus Fabr.

HEMIPTERA (Homoptera)

COCCIDAE

Paralecanium expansum quadratum Green.

CANAVALIA spp. (*C. ensiformis* (*L.*) *DC; C. gladiata* (*Jacq.*) *DC.*) (Haba)

COLEOPTERA

SCARABACIDAE

Xylotrupes gideon Linn.

CHRYSOMELIDAE

Lupermorpha serricornis Duv.

HEMIPTERA (Heteroptera)

PENTATOMIDAE

Coptosoma cincta Eschsch.

Nezara viridula Linn.

ORTHOPTERA

LOCUSTIDAE

Phaneroptera furcifera Stal

CINNAMONUM CAMPHORA (L.) Nees

HEMIPTERA (Homoptera)

COCCIDAE

Aspidiotus cydoniae Comst.

Aspidiotus destructor Sign.

CITRUS spp. (*C. aurantium Linn.*, Cahel; *C. aurantifolia* Swingle, Dayap, Limon; *C. grandis Osb.*, Lueban, Suha, Pomelo; *C. nobilis Lour.*, Narangita, Sitones, Mandarin or King Orange; *C. mitis* Blanco, Calamondin, Calamansi)

DIPTERA

TRYPETIDAE

Dacus ferrugineus Fabr.

HEMIPTERA (Homoptera)

COCCIDAE

Coccus elongatus Sign.

Lepidosaphes lasiantha Green.

Pseudococcus virgatus Ckll.

Pulvinaria psidii Mask.

COCOS NUCIFERA Linn. (Niog, Coco, Coconut)

COLEOPTERA

IPIDAE

Xyleborus perforans Woll.

CHRYSOMELIDAE
Plesispa reichei Chap.

HEMIPTERA (Homoptera)

FULGORIDAE
Nesokaha philippina Muir.

COFFEA spp. (Cafe, Coffee)

HEMIPTERA (Homoptera)

COCCIDAE
Pseudococcus lilacinus Ckll.
Saissetia oleae Bern.

CORYPHA ELATA Roxb. (Buri, Buli)

COLEOPTERA

CALANDRIDAE
Rhyncophorus ferrugineus Fabr.

SCARABAEIDAE
Oryctes rhinoceros Linn.

ELAEIS GUINEENSIS Jacq. (Oil Palm)

COLEOPTERA

SCARABAEIDAE
Oryctes rhinoceros Linn.

EUGENIA MALACCENSIS Linn. (Macopa, Macopa-calabao)

HEMIPTERA (Homoptera)

COCCIDAE
Drosicha townsendi Ckll.

GARCINIA MANGOSTANA Linn. (Mangostan)

LEPIDOPTERA (Heterocera)

LASIOCAMPIDAE
Eupterota fabia Cram.

GLYCINE MAX Merr. (Soja, Soy Bean)

HEMIPTERA (Homoptera)

PENTATOMIDAE
Nezara viridula Linn.

ORTHOPTERA

LOCUSTIDAE
Phaneroptera furcifera Stal

GOSSYPIUM spp. (Bulac, Algodon, Cotton)

LEPIDOPTERA (Heterocera)

NOCTUIDAE
Cosmophila erosa Hubn.

COLCOPTERA

CHRYSOMELIDAE

Lupermorpha serricornis Duv.

HEMIPTERA (Homoptera)

JASSIDAE

Nirvana philippinensis Baker mss.

ORTHOPTERA

LOCUSTIDAE

Phaneroptera furcifera Stal

PSIDIUM GUAJAVA Linn. (Bayabas, Guayaba, Guava)

HEMIPTERA (Homoptera)

Ceroplastes rubens Mask.
Drosicha townsendi Ckll.
Pseudococcus lilacinus Ckll.
Pseudococcus virgatus Ckll.
Saissetia nigra Nietn.

PSOPHOCARPUS TETRAGONOLOBUS (L.) DC. (Segidilla, Calamismis, Asparagus Bean)

LEPIDOPTERA (Rhopalocera)

LYCAENIDAE

Catacrysops cnejus Fabr.

SACCHARUM OFFICINARUM Linn. (Tuba, Caña Dulce, Sugar Cane)

HEMIPTERA (Homoptera)

FULGORIDAE

Perkinsiella bakeri Muir.

ORTHOPTERA

GRYLLOTALPIDAE

Gryllotalpa africana Pal. B.

SOLANUM MELONGENA Linn. (Talong, Berenjena, Eggplant)

LEPIDOPTERA (Heterocera)

NOCTUIDAE

Plusia eriosoma Doubl.

COLEOPTERA

CERAMBYCIDAE

Dihammus fistulator Germ.

HEMIPTERA (Homoptera)

JASSIDAE

Empoasca flavescens Fabr.
Nephotettix apicalis Motsch.

SOLANUM TUBEROSUM Linn. (Patata, Potato)

COLEOPTERA

COCCINELLIDAE

Epilachna 28-maculata Motsch.

TAMARINDUS INDICA Linn. (Sampaloc, Tamarindo, Sambac, Salomague, Tamarind)

LEPIDOPTERA (Heterocera)

ARCTIIDAE

Hyarias metarhoda Walk.

COLEOPTERA

IPIDAE

Stephanoderes tamarindi Hopk.

THEOBROMA CACAO Linn. (Cacao, Chocolate)

HEMIPTERA (Homoptera)

CAPSIDAE

Helopeltis antonii Motsch.

HEMIPTERA (Homoptera)

COCCIDAE

Phenacaspis inday Banks.

Pseudococcus lilacinus Ckll.

VIGNA spp. (*V. sesquipedalis* Linn. etc.) (Sitao, Cowpea)

DIPTERA

AGROMYZIDAE

Agromyza destructor Mall.

SCLEROTIUM DISEASE OF RICE[1]

By E. de Braganca Pereira

INTRODUCTION

Rice is cultivated in all parts of the tropics and sub-tropics, and constitutes the primary food crop in the Orient. Ninety-seven per cent of the world's production is grown in Southern and Eastern Asia and the adjoining islands.[2] Statistics show that more than 37,891,224 hectares (92,833,000 acres) were under cultivation for rice in 1916; the amount produced in that year being more than 47,206,482,722 kilograms (103,854,262,000 lbs.).[3] In the Philippines, rice is the staple food, and, according to the statistical data,[4] the area devoted to it in 1918 was 1,368.140 hectares; the total production, 919,272,280 kilograms; and the total consumption, 1,067,699,717 kilograms. From these figures, it is evident that this cereal is of great importance and consequently the best means of increasing the yield should be considered. From the viewpoint of agronomy, a great deal has been done in the Philippine Islands to improve the plant as far as its desirable characters and yield are concerned, but from the pathological standpoint, very little attention has been given to it.

The low yield is partly due to the diseases that badly affect the plant. Like other agricultural plants, rice is subject to the attack of diseases caused by parasitic fungi. Among the diseases caused by parasitic organisms, the *Sclerotium* stem rot does a great deal of damage, not only in the Philippine Islands, but also in other rice growing regions. This fungus enemy is found to infect rice irrespective of the age of the plant. The attack, however, has been found to be more serious in the case of the plants while in the seed beds.

It was the object of this work to study the character of the causal organism of *Sclerotium* disease of rice and its behavior. Also, practical suggestions for control or preventive measures from the results of the investigation were to be formulated. The investigation was carried on in the College of Agriculture during the college years 1919-1920 and 1920-1921.

SURVEY OF LITERATURE ON THE SUBJECT

Besides the insects which cause sterility of rice in Burma, *Sclerotium oryzae*, Catt., causes partial sterility and excessive late tillering. According to Butler (1), it is more important than any other of the panicle diseases. The fungus occurs in Madras (2), in Orissa and near Ranchi (3), and also in the rice fields in Japan.

Other species of *Sclerotium* which do damage to rice in Borneo and Noakhali, Eastern Bengal, are *Sclerotium glumale* Cos. and *Sclerotium irregulare* Miy. These occur also in Japan (4). Reinking (5) states that the fungus infecting

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[1] Thesis presented for graduation from the College of Agriculture, No. 133; Experiment Station contribution, No. 72.

[2] Year Book of the United States Department of Agriculture. 1916.

[3] Year Book of the United States Department of Agriculture. 1917.

[4] Statistical Bulletin 2, Philippine Bureau of Commerce and Industry. 1919.

the rice plant in the Philippines is the same one which causes damping off of various seedlings in the Philippines.

Sclerotium oryzae Catt. was first discovered by Cattaneo (4), in 1879, and found to cause great losses to the rice in Novara and Lombardy. Cattaneo's description covered the morphology of the fungus and the symptoms of the plant. Miyake later discovered the fungus in Japan, and it was collected also in India about 1912.

ECONOMIC IMPORTANCE

The *Sclerotium* disease of rice is present in practically all of the rice growing regions in the Philippines and causes a considerable amount of destruction in the rice fields.

The writer made several inspections of the rice fields on the College Farm as well as of a few fields in the neighborhood of the College. On June 5, 1920, seed beds planted to rice were visited. These seed beds included one hundred and twenty-six varieties of rice planted side by side and given the same treatment. The plants were about twenty to twenty-five centimeters in height at the time of inspection. The total number of plants in each seed bed as well as the number of infected plants were counted separately and the percentage of infection calculated therefrom and the results tabulated.[5]

It was found that only twenty-one varieties out of one hundred and twenty-six were not at all infected. Some varieties were more affected than others.

The varieties that showed no signs of infection were:

Dinumero	Sinampingit	Saryaya
Lanioyo	Ubanan (A)	Tinalahib
Macan	Ubanan (B)	Apostol
Malati	Kabago	Darog (red)
Mayoro	Kaboong	Darog (white)
Malinis	Kanut	Caviteña
Mimis (pahule)	Palaypay	Kalisod
Minalet (pahule)	Panili	Kololin
Sinipulet		

The following varieties suffered the greatest damage:—

Asucena	Ganado	Legantong
Binacal	Inatchupal	Lumbang
Bumaro	Itom	Macan
Cabatiti	Itom (mabaska)	Malagkit
Cotanti	Itom magong balay	Milagrosa
Castila a biit	Lampakan	Seda
Guinagracia		

In the latter part of July, the writer visited a rice field near the College Farm and observed that some patches which were invaded by weeds were damaged by *Sclerotium*. However, the injury, as shown by the outward appearance of plants, was not very great; only a few plants showed a diseased condition.

[5] Tables giving (1) varieties of rice infected with *sclerotium*; (2) measurements in millimeters of sclerotial bodies in (*a*) rice plants, (*b*) carrots, (*c*) potato agar, (*d*) corn meal are omitted because of lack of space. These tables are on file in the Plant Pathology Department, College of Agriculture. Copies will be sent to any one who may desire them.

Plants growing in soil fairly dry and free from weeds, and where they were not crowded, showed no sign of infection.

On September 8, 1920, two fields situated at the Experiment Station were visited. The plants were then three months old. In this particular case, the writer did not use the whole field for his observations; only a few patches in the field were selected at random. A number of plants were counted in each patch when this number and the number of diseased plants were recorded. From these data the percentage of damage was calculated. The results of this study are given in Table I.

TABLE I.—*Degree of infection of Sclerotium under different field conditions.*

No. of hills counted in each area.	No. of hills infected.	Percentage of infection.	Condition of soil.
42	6	14.28	Very weedy. Soil moist.
48	10	20.83	Very weedy. Soil moist.
42	none	—	Very few weeds. Soil dry.
51	4	7.84	Somewhat weedy. Soil moist.
45	5	11.11	Quite weedy. Soil moist.
45	none	—	Almost no weeds. Soil dry.
48	none	—	Almost no weeds. Soil dry.

Table I shows that plants in areas which were very weedy and where the soil was moist were badly infected; and that plants where the soil was free from weeds and fairly dry were free from disease.

The writer also observed the damage done in some rice paddies and found that plants growing too close together were attacked by the fungus while those growing far apart were healthy.

SYMPTOMS

The damage as observed in the rice fields at the College was rather serious during the seedling stage of the plants. Mycelial threads or hyphae were found to cover the surface of the ground at the base of the stem of the young plants. These gradually invaded the stem, browning it. White bundles of mycelium as well as pale yellow ones were observed on the stem of the attacked seedlings. Also a large number of brown sclerotial bodies were found on the injured plants. A large number of plants had been killed by the organism; and the living ones showed a stunted growth. When the plants were quite old the damage was not so serious as in the case of the seedlings, there being fewer infected plants than in the case of the young plants. The characteristic symptoms were late tillering and the production of light and poorly developed grains.

According to Shaw (4), the presence of *Sclerotium oryzae* Catt. on rice is characterized by late tillering or by the production of green shoots at the base of the culms, arising from the adventitious buds. The infected plants gradually turn yellow and die. The grains formed are usually light and poorly developed. The association of the fungus can be distinctly detected in the field by the late

tillering from the base. In Pusa (India), the appearance of the disease occurs when the rice is fairly advanced. On account of the loss of grain, it constitutes a most serious damage.

The diseased culms when dissected show the invasion of the fungus at the base, and the hyphae form within the pith cavity a dark grayish mass dotted with small black sclerotial bodies. The fungus may invade a node above the base. It not only penetrates the pith cavity, but it also ramifies the tissue of the culms invading the cells and forming sclerotial bodies in the main vascular bundles as shown by the cross sections of the diseased stems.

ISOLATION EXPERIMENTS

The causal organism was isolated either in the form of sclerotial bodies or from portions of mycelium. The cultures were kept on potato agar and corn meal and numbered from one to eight. A list of these cultures is given in Table II.

TABLE II.—*Cultures: giving host, method of isolation, and media used.*

Culture number.	Host.	Method of isolation.	Media used.	Date isolated.
1	Rice seedlings.....	By sclerotial bodies.....	Potato agar.....	Sept. 14, 1919
2	Stem of peanut.....	By sclerotial bodies.....	Potato agar.....	Oct. 19, 1919
3	Rice seedlings.....	Sterile cuttings of the stem..	Corn meal.....	Dec. 4, 1919
4	Rice seedlings.....	By sclerotial bodies.....	Potato agar.....	Feb. 9, 1920
5	Carrot.....	By sclerotial bodies.....	Potato agar.....	Feb. 20, 1920
6	Leaf sheath of sugar cane.....	By sclerotial bodies.....	Corn meal.....	July 8, 1920
7	Stem of rice seedling, one month old	By sclerotial bodies.....	Corn meal.....	July 10, 1920
8	Stem of rice plant..	By cuttings of the stem diseased stem.....	Potato agar.....	Sept. 8, 1920

Culture 1 was isolated from rice seedlings by means of sclerotial bodies, which were sterilized in mercuric bichloride (1:1000), and passed through three successive washings of sterilized water and then transferred to a potato agar plate. The same process of isolation was followed in Cultures 2, 4, 5, 6, and 7, except that the medium used in Cultures 6 and 7 was corn meal. These cultures were isolated from the stem of peanut, carrot, leaf sheath of sugar cane, and rice seedlings, respectively. Cultures 3 and 8 were isolated from sterile cuttings of the infected stems of rice, and the media used were corn meal and potato agar, respectively. The isolation was made in an isolation box in a room free from draft. The transfer from one container to the other was made by means of a sterilized platinum loop when sclerotial bodies were used and with a point of a flamed scalpel when sections of diseased stems were used.

ARTIFICIAL INOCULATION EXPERIMENTS

INOCULATION OF RICE

Inoculation experiments were carried out on rice seedlings as well as on full-grown rice plants. The inoculated seedlings were placed either in bell jars,

in a damp chamber, or in the open air under shade. The mature plants were kept in the open air under shade. The inoculation was made in young plants by placing a portion of mycelium from a pure culture with a sterilized platinum needle at the base of the stem. Large plants were inoculated by introducing a portion of mycelium in the leaf sheath. A piece of moist cotton was placed around the base of the stem. As inoculations with old cultures were unsuccessful, a three days old culture when the hyphae were growing vigorously and no sclerotial bodies were yet formed, was used. The results obtained are given in Table III.

TABLE III.—*Rice inoculations.*

Culture number.	List of plants inoculated.	Date of inoculation.	Conditions to which plants were subjected.	Extent of damage.
1	3 pots of rice seedlings, five days old.....	Sept. 24, 1919.	Under the bell jar.....	Slight
2	2 pots of rice seedlings, one month old.....	Oct. 27, 1919..	In the damp chamber..	Serious
3	3 pots of rice seedlings, 11 days old.....	Dec. 4, 1919..	In the damp chamber..	Badly infected
4	25 rice plants (grown up).	Feb. 12, 1920.	In the field.....	Not very serious
6	3 pots of rice seedlings, one and a half months old..	July 17, 1920..	In the bell jar.....	Slight
7	4 pots of rice seedlings, 25 days old.....	July 25, 1920..	In the open air, shaded place.....	Slight
8	25 grown up plants.....	Sept. 15, 1920.	In the field.....	Badly damaged
4	3 pots of rice seedlings, 20 days old.....	Dec. 12, 1920.	In the damp chamber..	Slight

As shown in Table III, seedlings kept in the damp chamber were seriously damaged, while those kept under the bell jars suffered little. The grown up plants did not suffer as much as the seedlings. The spread of the fungus was rapid on plants kept in the damp chamber. Plants inoculated with cultures kept for a long time in artificial media produced slight infection and did but little damage; while cultures which were quite fresh caused severe injury. The attack was particularly fatal to the seedlings. Older plants were fairly resistant to infection and only in a few cases were they killed by the organism. The virulence of old cultures was probably less, due to their adaptability to artificial media.

Seeds of Binacal variety were planted in eight different seed flats. Four of these contained soil mixed with sawdust in the proportion of 3:1 and four, garden soil On August 12, 1920, four seed flats, two containing sawdust and two, garden soil, were inoculated with a portion of mycelium from Culture 7; and four seed flats, two containing sawdust and two, garden soil were used as control. Two seed flats, one of which contained sawdust, were placed in the open air, and the other one in a rice field which was kept always flooded. The remaining four out of the eight boxes were given the same treatment except the addition of mycelium. The observations made in the experiment are given in Table IV.

TABLE IV.—*Inoculation of rice seedlings in seed flats.*

Number.	Date of inoculation.	Contents of seed flats.	Conditions under which subjected.	Degree of infection.
1	Aug. 12, 1920.	Garden soil with sawdust.....	In the open air, under shade	Badly infected
2	Aug. 12, 1920.	Garden soil with sawdust.....	Flooded in the paddies.....	No infection
3	Aug. 12, 1920.	Garden soil alone....	In the open air, in shade....	Slight infection
4	Aug. 12, 1920.	Garden soil alone....	Flooded in the paddies.....	No infection
5	Control.....	Garden soil with sawdust.....	In the open air, in shade....	No infection
6	Control.....	Garden soil with sawdust.....	Flooded.....	No infection
7	Control.....	Garden soil alone....	Flooded.....	No infection
8	Control.....	Garden soil alone....	In the open air, in shade....	No infection

From Table IV, it is evident that plants in moist soil mixed with sawdust were very badly infected. The infection was rapid. Those in pure and moist garden soil were infected to a less degree than when there was sawdust. The inoculated plants kept flooded showed no symptoms of diseased condition. The seedlings which served as control remained healthy.

In order to further prove that the *Sclerotium* attacking the rice plant is a parasitic organism, the following experiment was performed. Seeds of rice were sterilized in a 1:1000 solution of mercuric bichloride and then passed through three successive washes in sterilized water. They were then transferred by means of a sterilized platinum loop to the potato agar plate and left to germinate. When the seedlings were five days old, eight of them were selected and transferred to eight different long test tubes containing agar medium. Three days later, May 3, 1920, these seedlings were inoculated with Culture 5. This was done by placing one sclerotial body from the culture on each seedling. Within twenty-four hours all the sclerotial bodies germinated. The fungus spread rapidly on the seedlings, and as a result they gradually turned yellow and died. Within a week, sclerotial bodies of spherical shape and of a brown color were formed on the stem of the plant as well as on the walls of the tube.

CROSS INOCULATIONS

To find out whether the fungus causing damage on rice plants attack other plants, a series of cross inoculations were made, using Cultures 3 and 4. Every precaution was taken to prevent contamination. The soil was sterilized before planting the seeds of the various succulent plants used in the experiment. Control seedlings were maintained on which all other treatments were made except the addition of the mycelium. All remained healthy. All re-isolations made were positive.

INOCULATION OF SOY BEANS

On April 2, 1920, young seedlings of soya bean which were planted very close together in an earthen pot were inoculated with Culture 3. The plants were inoculated with a bit of mycelium which was placed at the base of the stem

by means of a sterilized platinum needle. The inoculated plants as well as the control plants were kept in a damp chamber. More than 50 per cent of the plants were severely infected. This was shown by the spread of the white mycelium first at the base of the stem and then gradually up to the leaves. As a result the stem turned brown, the plant began to wilt, and the leaves gradually turned yellow. All infected plants died on the fourth day after inoculation.

INOCULATION OF NEW ERA COWPEA

The New Era cowpea seedlings were inoculated on April 2, 1920, with Culture 3. The plants were infected but the attack was not very severe. Some of the plants died, while the rest only showed an unhealthy appearance. The methods of inoculation were the same as those used in the soy bean inoculation. Both the infected and the control plants were kept in a damp chamber. Forty-eight hours after infection, the fungus was found to have invaded the plants. The stem turned brown and the plants wilted as a result of the attack.

INOCULATION OF GARDEN PEAS

The same means as used with cowpea were employed to inoculate the seedlings of garden peas. The plants were inoculated on the same date as the soy bean seedlings and the seedlings of the New Era cowpea. The damage done was little. Only a few plants died, but the rest were stunted. The development of the mycelium was very slow and it took nearly three days to spread and invade the plants. The result obtained was practically the same as in the other two cases, that is, the rotting of the stem and wilting.

INOCULATION OF MOUNTAIN PEPPER

Seedlings of mountain pepper eleven days old were inoculated on April 2, 1920. In this experiment Culture 4 was used instead of Culture 3. A portion of mycelium was placed on the soil at the base of the seedlings by means of sterilized platinum needle. Control seedlings were given the same treatment except the addition of the fungus. The inoculated plants as well as the control were kept in a damp chamber. After forty-eight hours, it was observed that all the plants were infected and practically all the seedlings were killed. The organism attacked the stem first, and then gradually invaded the leaves. After the fourth day, a white mass of mycelium covered the young plants entirely and sclerotial bodies began to appear.

INOCULATION OF CALAMISMIS

Calamismis seedlings were inoculated with Culture 4 on April 2, 1920, using the same methods employed with the other plants. The result obtained was practically the same as in the inoculation of mountain pepper. The damage caused by the organism was great. All of the plants were invaded and eventually killed. The sclerotial bodies were formed on the stem after five days.

INOCULATION OF PEANUT

Seedlings of peanut ten days old were used in this experiment. The young plants were inoculated with Culture 4 on April 2, 1920. A small portion of the mycelium was transferred from the tube to the stem of the young plants with a sterilized platinum needle. The fungus spread within twenty-eight hours. After forty-eight hours all of the plants were badly affected. The stems turned

dark brown first and then almost black. The mass of mycelium spread not only on the stem but even on the leaves. As a result, the latter turned yellow and the plants were all killed. The peanut seedlings were the ones which suffered the most. Within five days all the plants succumbed. The characteristic change which took place in the fungus was that the sclerotial bodies were smaller than those found in other plants, but when isolated produced sclerotial bodies of the same size as in other cases.

INOCULATION OF PEPPER

Young plants, twelve days old, were inoculated with Culture 4, on April 2, 1920, using the same methods as with the other plants. The infected plants showed the same symptoms as the mountain pepper seedlings, but the attack was far more severe. A larger percentage were killed and practically all of the plants were victims of the infection. However, the attack was not so severe as in the case of peanut seedlings. The characteristic symptoms were the browning of the stem and later the yellowing of leaves. The mycelium infected the stem first and gradually spread on the leaves; eventually the seedlings were covered. All of the plants were ultimately killed.

INOCULATION OF PAPAYA

On April 2, 1920, a large number of papaya seedlings, twelve to thirteen days old, planted in earthen pots, were inoculated with Culture 4. The same methods of inoculation and the same treatment as in the previous tests were employed. The plants were all infected and practically all of them were killed by the fungus. The attack was almost as severe as in the case of peanut seedlings. The mycelium spread at the base of the stem first, gradually rising to the leaves. The stem turned brown and the plants wilted and bent towards the ground. The leaves turned yellow and finally the plants dried out. The control plants showed no signs of infection.

INOCULATION OF SESAMUM

Seedlings of sesamum were inoculated with Culture 4 on April 2, 1920. The seedlings were planted very close together in earthen pots. After forty-eight hours the mycelium spread all over the pot at the base of the stem, gradually going up the stem and infecting the leaves. The stems wilted and bent. Eventually the leaves were attacked. The attack was very severe and all the plants died. White strands of mycelium could be seen developing on the affected plants.

INOCULATION OF SQUASH

Young squash plants growing very close together were inoculated on April 2, 1920, with Culture 4. A small portion of mycelium was placed on the stem. Within forty-eight hours, the mycelium developed and invaded the stem inoculating it and spreading on the neighboring plants. The characteristic browning of the stems, followed by the wilting of the plants, was observed. As the invasion of the fungus progressed, the leaves turned yellow and the plants died. Only two or three plants survived out of the whole lot.

CAUSAL ORGANISM

MORPHOLOGY

In order to make a study of the character of the fungus isolated in pure culture, the organism was examined under the high power of the microscope

and drawings of mycelium and sclerotial bodies were made from fresh specimens with the aid of a camera lucida. The morphological study upon the structure of the vegetative parts was made from pure cultures on potato agar. The descriptions of mycelium and sclerotial bodies were made from the mounted specimens also obtained from pure culture on the same medium.

Mycelium.—The mycelium of all cultures grows very abundantly in masses. Under the high power of the microscope, it is hyaline. The mycelial threads are septate and branched at right angles. They are granular when young, but when old they are not. The septations occur at the origin of a branch and not far from it. The cells of mycelium were measured with the aid of eye piece micrometer. Portions of mycelium from Culture 4 grown on oat agar and potato agar were spread on separate slides and measured. The size of the cells varies from 104 microns to 238 microns in length, and from 4 microns to 6 microns in width in oat agar; and from 112 microns to 24 microns in length and from 4 microns to 6 microns in width in potato agar.

Sclerotial bodies.—The sclerotial bodies are roughly circular and vary in diameter from 0.76 millimeters to 1.15 millimeters when growing on potato agar. Shaw (4) reports that sclerotial bodies grown on glucose agar vary in diameter from 0.15 millimeters to 0.50 millimeters. Sclerotial bodies are formed by the interlacing of hyphae which continue to branch and intertwine until a small spherical compact mass is formed. This spherical mass enlarges by the addition of the new branches of mycelium and finally the cell walls turn dark brown and the growth stops. By this time, the inside of the sclerotial bodies is a definite parenchymatous structure which cannot be discerned to have come from the interweaving of hyphae, although a loosely intertwined hyaline hyphae can be seen within. On corn meal several sclerotial bodies may become united resembling a stroma in appearance.

One hundred sclerotial bodies taken from potato agar and one hundred from corn meal were measured with the aid of a micrometer caliper and the measurements tabulated.

The sclerotial bodies grown on potato agar varied in diameter from 0.76 to 1.15 millimeters; and those grown on corn meal varied from 0.63 to 1.25 millimeters.

Fifty sclerotial bodies collected from rice plants and fifty from carrot plants were measured with a micrometer caliper and the measurements tabulated.

The data showed that there was not much difference in the measurements of the sclerotial bodies on rice and on carrot. Sclerotial bodies from rice plants varied in diameter from 0.70 to 1.15 millimeters while those from the carrot plant varied from 0.68 to 1.12 millimeters.

Spore forms.—In the Philippines, no spore form has been found. The writer followed the method used in Japan for the artificial production of spores. Four flasks one-third full of rice matting were sterilized. A portion of mycelium was transferred from Culture 3 on April 26, 1920. On May 6, when the mycelium was well developed, the flasks were placed under different conditions of light and temperature. Flasks one and two were placed in an ice box but under different thermal conditions; number one being in the colder compartment, the temperature of which was between 9° to 10° Centigrade, and number two

being in a compartment where the temperature was between 18° and 22° Centigrade. Flask three was placed in the dark and flask four in a pigeon-hole in a case.

The first observation was made on May 8. The main difference in the behavior of the organism was that the largest number of sclerotial bodies were produced in the flask number four, a slightly smaller number in flask number three; flask number one produced the least number of sclerotia, flask number two coming next.

Observations were made under the microscope, at intervals of one or two weeks, to see whether there were any spores produced. No spores could be detected.

As to the outward appearance of the fungus, a fuzzy mass of mycelium was observed in flasks one and two, to a slight extent in flask number three, but none in flask number four.

The sclerotial bodies were borne in stalks in all three flasks; they were large in size and many in number in flask four; they were comparatively few in flasks one, two, and three, the first producing the smallest number and tiny in size. The sclerotial bodies kept in the coldest compartment took by far the longest time to change to their last stage, that is, from white to brown.

PHYSIOLOGY

A study of the growth of pure cultures of *Sclerotium* was made on eight different sterilized media. The cultures were placed in three different places. Three tubes of each kind of medium were used. Number one was placed in an ice box, number two in a dark place, and number three in the laboratory. The cultures grew best on corn meal and bread medium; they grew fairly well on other media, except on filter paper where very few sclerotial bodies were produced, and the mycelium grew very little. Observations were made daily at the beginning of the experiment for a period of one week and then weekly for more than a month and a half. Sclerotial bodies of the same age were transferred on all media, one in each tube.

Growth on potato agar.—On May 28, 1920, a sclerotial body from Culture 4 was transferred into each of the three fresh potato agar tubes by means of a sterilized platinum loop. Only one sclerotial body was used for the purpose of comparison. The test tubes were placed in three different places as already stated.

After twenty-four hours, it was found that the mycelium grew best under ordinary laboratory conditions. The growth was very slow in the cold temperature. Sclerotial bodies began to form after four days in the tubes kept in darkness and in those under ordinary laboratory conditions, while in the case of the medium kept in the ice box, the formation of sclerotial bodies was observed after seven days. After five days the mycelium in the medium kept under ordinary laboratory conditions showed some yellow patches near the margin. The same phenomenon occurred in tubes one and two, but after a longer period. The sclerotial bodies in tubes two and three matured earlier than those in tube one.

The mycelium in the medium kept in the ice box grew very fast after six days and spread all over the tube, reaching the cotton plug. The characteristic

behavior of the fungus on the potato agar medium was, that it always grew on the walls of the tube and away from the medium.

The first tube was characterized by the development of mycelium which was hairy in consistency and by the production of a less number of sclerotial bodies than in the other two test tubes. The mass of mycelium in the first tube was thinner than that in the other two tubes.

Corn meal.—On May 28, 1920, a cultural study was made on corn meal by the same method employed with the potato agar.

The fungus germinated within twenty-four hours in tubes two and three, but failed to germinate in tube one (kept in ice box). The hairy hyphae spread over the medium, the growth being faster in the case of tube number three. The sclerotial body in tube one germinated after forty-eight hours. The growth of mycelium was rather slow. After four days, the formation of sclerotial bodies was evident in tubes two and three, while it took place after five days in tube one. The mass of mycelium was thick and white at first, but gradually a yellow margin was evident. This characteristic change occurred first in tubes two and three and after two days in tube number one. Gradually yellow patches were observed in the three tubes. The sclerotial bodies were evident after four days in tubes two and three while it took longer in the case of tube number one. The characteristic behavior of the organism in this medium was the formation of the sclerotial bodies not only by the walls of the tube but also in the center of the tube and even at the bottom. The shape of the sclerotial bodies was rather irregular on the sides of the test tube, and they were rather large on the sides and also the bottom of the tube. The sclerotial bodies in the center of the tube were more regular in shape and smaller in size. A yellow liquid began to ooze out from the mycelium after a month and a half from the time of the transfer. After about two months, the mycelium became shriveled up and rusty brown patches were evident.

Glucose agar.—The sclerotial body germinated after twenty-four hours in tubes one and three, while in tube two it germinated after forty-eight hours. The sclerotial bodies did not begin to form at the same time in all the three tubes. Tubes number one and number two produced the sclerotial bodies earlier than tube number three. The mass of mycelium in this case was cottony in appearance and did not spread above the medium as the organism grown on potato agar or corn meal. Sclerotial bodies were borne in clusters and were small and somewhat irregular in shape. There was a little variation in the appearance of the mycelium. It was more cottony in tube number three, but at the extremities the mycelial threads seemed to be singly spread by the walls of the tube.

Citrus decoction agar.—On May 28, a cultural study on citrus decoction agar was made by the same method as employed in the previous observation. The fungus germinated the following day in all the three tubes but the rate of growth was faster in tube three. The sclerotial bodies began to form after four days in tubes two and three while in tube number one there was evidence of sclerotial bodies only after nine days. The growth of mycelium was cottony in tubes two and three while in tube one the appearance was similar to that grown on potato agar medium. The sclerotial bodies in all of the three tubes were irregularly scattered. The peculiar behavior of the organism in this

medium was that it produced sclerotial bodies on stalks and the bodies were lighter in color than those found on potato agar or on corn meal.

Bread medium.—On June 28, sclerotial bodies from Culture 3 were transferred into three different test tubes containing bread medium. The same method was followed as in the case of the other media. The growth of mycelium was at first slow, particularly in the medium kept in the ice box. The germination took place after twenty-four hours in all three tubes, but the rate of growth was faster in tubes two and three. The mycelium became thicker and thicker and practically resembled the mycelium grown on corn meal. The characteristic changes observed on corn meal were also observed on bread medium. After five days, yellow patches which eventually changed to brown, were observed. The characteristic shriveling of the mycelium on corn meal was also observed in bread medium. The shape and size of the sclerotial bodies was practically the same as on corn meal. The mycelium developed best in numbers two and three. The sclerotial bodies were more numerous in tubes two and three and their distribution was in groups in the center of the tube. The latter characteristic was observed in all the three tubes.

Oat agar.—A cultural study of the organism was made on oat agar medium on May 28, 1920. The method used was the same as in the other media. The sclerotial bodies germinated within twenty-four hours in all the three tubes. The appearance of the mycelium was similar to that on potato agar. Its rate of growth in tube two was faster than in any other medium and its consistency was thick in relation to the other two tubes. At the end of the fourth day, the formation of the sclerotial bodies was observed in tubes one and two. In tube three the sclerotial bodies were evident two days later than in the other two tubes. The mycelium was rather hairy and the sclerotial bodies were borne in groups. The shape of these bodies was somewhat round and regular and their color was light brown. After six days, yellow patches scattered all over were noticed on the mycelium of tubes one and two and a day later on that of tube three. Tube one produced the least number of sclerotial bodies but the mycelium developed and grew well. Tube three produced the largest number of sclerotial bodies.

Rice agar.—On May 28, 1920, three tubes containing this medium were used for the cultural study of the organism. They were given the same treatment as with the other media. The germination of the sclerotial bodies took place within twenty-four hours in all of the three tubes. The mycelial strands were thin and well spread all over the tube, almost the same in appearance as in oat agar medium. The sclerotial bodies were of the same color and size as those observed in oat agar, but scattered irregularly. About one month later, the mycelium became very thin and almost invisible in tube number one while it was a little thicker in tube two. Tube three produced the largest number of sclerotial bodies. The color of the bodies in rice agar as well as in oat agar was light brown like those found on the rice plant itself.

Filter paper.—On May 28, 1920, a transfer of sclerotial bodies was made from Culture 3 to three tubes of filter paper medium, using one sclerotial body in each tube as with the other media. The same treatment, also, was given as with the other media. The germination of the sclerotial body took place after twenty-four hours. The development of the mycelium in tube one was better than in the other tubes or even in the tubes of any of the other seven media. The

mycelium consisted of a thin mass of hyphae spreading on the medium. Tube one showed a luxuriant growth of mycelium after forty-eight hours while the mass of mycelium grew very little in the other two tubes. After four days, the mycelial strands were not thin and hairy, but on the contrary, a cottony growth was observed. After this time, the mycelial growth was very slow. Sclerotial bodies appeared within four days in all three tubes. They were very few in number, their shape was peculiar, and their size very tiny. They spread irregularly all over the medium. After about twenty days the mycelium almost stopped growing.

TAXONOMY

The study of the behavior of *Sclerotium* in pure cultures, the similarity in appearance of the mycelial strands, and the shape of the sclerotial bodies in different media, seemed to show that the organism was identical in all of the cultures.

Sawada places *Sclerotium oryzae* Catt. under the genus *Hypochnus*. The fungus with which the writer worked belongs to the genus *Sclerotium* because of its septate mycelium branching at right angles, and because of the sclerotial bodies which are spherical in shape and smooth surfaced.

No attempt was made to study the species to which this genus belongs.

SEASONAL CYCLE

It was observed that the sclerotial bodies germinated when the soil was moist. A temperature a little higher than that in the laboratory was favorable for their growth. The hyphae spread on the soil at the base of the plant and gradually grew upward and invaded the stem. They in turn joined themselves into bundles. These bundles gradually hardened and took a brown color, transforming into sclerotial bodies. The latter remained in the soil until favorable conditions arose again. According to the observations made by the writer, the sclerotial bodies were able to live in the soil for twelve or thirteen months when kept under moist conditions and for about five or six months under dry conditions. It was found, also, that sclerotial bodies germinated even after seven months on artificial media. The following experiments were performed to find the longevity of the sclerotial bodies. Two pots with sterilized soil were kept out of the laboratory, one of these always being kept moist while the other was kept dry. Both of these pots were examined every month as to the viability of sclerotial bodies by taking sclerotial body from each pot and growing it on potato agar. The experiment was continued until the sclerotial bodies failed to germinate.

DISCUSSION OF RESULTS

It was found that the fungus behaved somewhat differently as far as the appearance of the mycelium and sclerotial bodies are concerned in some media, particularly in corn meal, bread, and filter paper. However, morphological study showed that the organism had only one type of mycelium. The organism grown on rice matting produced stalks on which *Sclerotia* were borne. Another characteristic feature was the formation of a fuzzy mass in cold temperature. The phenomenon was not observed under ordinary room temperature.

The cross inoculation experiments seem to indicate that the *Sclerotium* is able to produce disease when transmitted from host to host. Cultures kept for a long time in artificial media did but little damage; this is probably because the fungus was accustomed to the artificial medium, thus becoming less virulent.

Temperature slightly higher than that in the laboratory seemed to favor the growth and development of the organism.

It was observed that moisture was favorable for proper development of the organism. This was shown by the fact that most of the inoculations carried on in the damp chamber were very successful, destroying the host in a very short time. Rice plants under the bell jar took a longer time to be infected and the damage caused was slight.

Rice seedlings in seed flats containing soil mixed with saw dust were completely destroyed, probably because the saw dust helped to keep the soil moist enough for the development of the organism; seedlings in the same kind of soil with saw dust, but kept under water, were not at all subject to the disease.

Plants growing among weeds suffered very much from fungus invasion, while those growing on patches which were fairly dry and free from weeds showed no signs of invasion.

Plants growing too near each other showed the largest percentage of infection, while those growing far apart were practically free from disease.

In the case of mature plants, the characteristic symptoms of infection were late tillering and the presence of distorted ears.

It was found that the following varieties were free from disease: Asucena, Binacal, Bumaro, Cabatiti, Colanti, Castila a biit, Guinagracia, Ganado, Inatchupal, Itom, Itom (mabaska), Itom magon balay, Lampatan, Legantong, Lumbang, Macan, Malagkit, Milagrosa, and Seda.

SUMMARY AND CONCLUSIONS

1. Sclerotium which attacks the rice plants in the Philippines was also found to infect the following plants:— Soy bean, mountain pepper, peanut, New Era cowpea, calamismis, pepper, and sesamum.

2. The damage to rice seedlings caused by *Sclerotium* went as high as 34.44 per cent.

3. Close planting and lack of maintenance of clean cultures promoted the development of the disease.

4. Older plants transplanted in soil infected with *Sclerotium* produced late tillering and distorted ears.

5. Inoculations by means of mycelium were more effective than those with sclerotial bodies.

6. Cultures kept for a very long time on artificial media seemed to develop very slowly on the inoculated plants and produced only a slight injury.

7. Dampness favored the growth of the organism, for the inoculated plants placed in the damp chamber were affected in a shorter time than the ones outside. Also field inoculations supplied with extra moisture gave better results than those which were not supplied with any extra moisture.

8. The organism isolated from one host could not be distinguished from that isolated from another, when the cultures were kept on the same kind of medium.

9. Morphological study showed that there was one general type of mycelium, but the size of sclerotial bodies varied when grown on different media.

10. Under ordinary laboratory conditions, the fungus grows best in soil mixed with saw dust.

11. Plants growing in flooded soil showed no signs of disease.

12. The following varieties were badly affected by *Sclerotium*:—Asucena, Binacal, Bumaro, Cabatiti, Colanti, Castila a biit, Guinagracia, Ganado, Inatchupal, Itom, Itom (mabaska), Itom magong balay, Lampakan, Legantong, Lumbang, Macan, Malagkit, Milagrosa, and Seda.

13. Twenty-four varieties were free from disease. The list below gives the names of these varieties:

Dinumero, Lamoyo, Macan, Malati, Mayoro, Malinis, Mimis (pahule), Minalet (pahule), Simpulet, Sinampingit, Ubanan (A), Ubanan (B), Kabagay, Kaboong, Kanut, Palaypay, Penili, Saryaya, Tinalahib, Apostol, Darog (red), Darog (white), Caviteña, Kalisod, and Kolelin.

14. The organism is a facultative saprophyte, belonging to the genus *Sclerotium*.

RECOMMENDATIONS

The recommendations formulated in this paper are based upon observations and the results of experiments.

1. Close planting in seed beds as well as in the field should be avoided.

2. The seed beds as well as the rice fields should be kept as free as possible from weeds.

3. Paddies should be kept always under water.

4. Cattaneo (4) suggests the application of sal ammoniac to kill the *Sclerotia* in the soil. This may be successful on a small scale but impracticable on a large scale because of the high cost of chemicals.

5. Resistant varieties should be used.

6. Reinking (5) suggests that "all soil used for the growth of seedlings should be sterilized in case the disease is severe."

ACKNOWLEDGMENT

The writer is greatly indebted to Prof. Otto A. Reinking of the Department of Plant Pathology for his advice and suggestions throughout the progress of the work.

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Science and literature are not two things, but two sides of the same thing.—*Huxley.*

HOG CHOLERA AT THE COLLEGE OF AGRICULTURE[1]

By B. M. Gonzalez
Of the Department of Animal Husbandry

Hog cholera broke out among the hogs of the College recently. Pigs varying in age from four months to about three years were affected in a similar manner. The total number of hogs that died was 36 out of a total number of 56 pigs in the herd, thus giving a mortality of about 64 per cent. The period of incubation was noted as varying from one day to twenty-one days, with an approximate average of nine days.

At current prices of pork in the Los Baños market, ₱1.20 a kilogram, and a dressing percentage of 75 per cent, the total loss sustained by the College amounted to about ₱1,200.00. This money value does not represent all the loss, for the greater proportion of the animals were of a superior breed, three-quarters Berkshire, used in "grading up" experiments.

The College possessed at the time three pure breed Berkshires. These showed the first symptoms of the infection, but all three recovered. For treatment, a dose of epsom salts was given, followed by an enema. Before being infected the animals were in a very healthy condition, and this, probably, more than anything else, saved them. Only two cases of recovery were noted. These animals recovered from the disease very much emaciated; both regained their former condition rapidly.

The symptoms noted in the hogs affected were an increased temperature, a general dejection, lack of appetite, weakened hindquarters, and a staggering gait. The eyes were sensitive to light and watered, and the exudation tended to make the lids stick together. There were light abrasions on the belly. Constipation was usually present, and occasionally diarrhea. The post mortem examination usually disclosed congested lungs, and button ulcers in the intestines, especially at the caecum, about the ileocecal valve. Petechial hemorrhages were frequently noted in the kidneys. Two pregnant sows aborted shortly before death, and on post mortem examination a few more pigs were found inside. Judging from the symptoms, the disease was probably caused by a combined infection of hog cholera and swine plague. Another post mortem finding which had no bearing on the infection, but which showed a condition that may have hastened the death of certain animals, was the presence of kidney worms in many of the pigs; the worms had caused injury in varying degrees of severity, from light lesions in the liver to almost absolute obstruction of the ureters.

The probable source of this infection was a grade Berkshire sow brought in from Camp Eldridge for breeding. This animal was kept in the weighing compartment 12 days. During this period, the usual monthly weighing was made and all the animals had access to the room.

An inquiry as to the history of this sow shows that it had been bought by the Army Post from an American farmer in Los Baños. The sow had been kept at the Post about one month before she was brought to the College for breeding. About a month after her return to the Post the other pigs of the Post herd began

[1]Experiment Station contribution, No. 73.

to die. The sow was never sick herself, but fearing that she might become so, and inasmuch as she was not breeding, she was butchered early in October, 1919. She was healthy while at the College but never came in heat for breeding. The indications are strong that she was a virus carrier.

Hog cholera is the most serious disease of hogs known, and causes about 90 per cent of all deaths of these animals. The most effective of the available methods of combating it are sanitation, isolation, and prophylaxis. All measures that promote the health of the animals tend to increase their vitality and their power to resist disease. It is believed that hog cholera virus increases in virulence as it passes from host to host. It is, therefore, important that the pigs be healthy in order that they may resist the disease while its virulence is low.

When an animal appears sick, it should be immediately isolated. Thorough and frequent disinfections of the trough and quarters should be made, and all mud holes and insanitary wallows should be filled and disinfected. It is best to divide the herd into small units in isolated compartments so as to localize the infection. No other animals should be allowed on the premises. When an animal dies, it should be burned or buried deep in a place where neither hogs nor other animals that may spread the infection will have access to it; and where the drainage of the ground is away from places where hogs are kept.

The United States Department of Agriculture has discovered the protective property of blood serum from immune pigs. This injected into susceptible pigs has been the means of saving large and valuable breeding herds. But none of this product has been prepared in the Islands so far, and it is not practical to bring it from abroad.

PLANT DISEASES FOUND AT TRINIDAD IN DECEMBER 1921[1]

By Colin G. Welles
Of the Department of Plant Pathology

A brief survey of the plant diseases in the large market gardens at Trinidad, Mountain Province, was made during the latter part of December, 1921.

The temperature of this region, due to the high altitude, is rather low compared with the rest of the Philippines. Because of this comparatively low temperature garden crops which are generally confined to a temperate climate are raised successfully.

The most serious disease prevalent during the period in which observations were made, was the late blight of potatoes, caused by *Phytophthora infestans* (Mont.) De Bary. According to Mr. Wright, Superintendent of the Trinidad Farm School, this disease is the limiting factor in Irish potato production. Likewise the disease is very serious on tomatoes and is also the limiting factor in their production.

Late blight is easily checked by spraying with Bordeaux mixture every two weeks throughout the growing season; so the loss which has hitherto resulted from this disease may be entirely prevented.

The disease next in importance is the black rot of cabbage caused by *Pseodonas campestris* (Pammel) E. F. S. While observation disclosed that less than one per cent of the plants suffered severely, fifty per cent of the plants were parasitized to some extent. The lesions were confined to the margins of the leaves,

[1]Experiment Station contribution, No. 74.

rarely penetrating more than five centimeters. Likewise, the blackening of the vascular elements was not perceptible any distance from the margin. The loss at present is not great but it may spread at any time under optimum conditions and threaten the cabbage industry.

No good control measures have been worked out for this disease, but black rot may be reduced by treating seed for fifteen minutes with mercuric chloride, 1-1000; by planting only seedlings which appear perfectly healthy; and by the removal of all diseased plants from the field.

Other diseases which have been identified are:

(1) Leaf spot of strawberry caused by *Mycosphaerella fragariae* (Tul.) Lindau. However, in this case the imperfect stage (*Ramularia tulasnei*) was the only stage found. The disease may be controlled by the removal of the affected leaves and by spraying with Bordeaux mixture. This is necessary only in severe attacks.

(2) Leaf spot of celery caused by *Cercospora apii* Fr. This disease is not serious and as it appears mainly on old leaves no control is needed.

(3) Leaf spot of beet caused by *Cercospora beticola* Sacc. The disease, not being serious, requires no special attention.

(4) Rust of bean caused by *Uromyces appendicalatus* (Pers.) Lev. This rust is very serious at the present time and according to Mr. Wright becomes wide-spread, attacking all varieties of beans with one exception. The exception is a red variety of *P. vulgaris*. An attempt might be made to cross the red variety with others and develop more resistant strains. No other practical means of control is known at present.

(5) Leaf spot of sweet potatoes caused by *Cercospora* sp. The leaf spot is not severe but reduces the photosynthetic area of the leaf perceptibly. The species of *Cercospora* has not been determined but it may be *C. batatae* Zimm., the species commonly found in China and at Los Baños, Laguna. The lesions on the host at Trinidad are neither as large nor as black as those observed at Los Baños, but no conclusion can be drawn from this since the varieties are different, the one in Los Baños being a local variety while the one at Trinidad has just been imported from the United States.

If severe, control may be obtained easily by spraying once in two weeks with Bordeaux mixture. This process, however, will probably give little economic benefit.

The remarkable freedom of the garden crops at Trinidad from disease is striking and strict measures should be employed to exclude all pathogenes and to prohibit further disease introduction. It would be well to treat all imported seed with formalin or mercuric chloride.

ABSTRACT[1]

The effects of fertilizers added to soil on the growth of roselle plants and production of fiber, Teodorico P. Reyes. (*Thesis presented for graduation from the College of Agriculture, No. 134; Experiment Station contribution, No. 75*). —This investigation was of a preliminary nature and makes no claim to have determined completely the fertilizer requirement of roselle. It deals primarily with the growth and production of fiber of roselle plant (*Hibiscens sabdariffa* L.) as affected by different sets of proportions of commercial fertilizers applied to the soil.

The results showed that the efficiency of fertilizers depends upon their quality, amount of application, their proportion, and the nutrient substances found in the soil. In all cases the fertilizers gave favorable effects on the height of the roselle plant irrespective of the fertilizer proportions. The best results were obtained when N-bearing fertilizers were applied in sufficient amount and with the addition, in small amounts, of P-bearing and K-bearing fertilizers. As to the average height of the plant, the poorest fertilized plot gave higher average weight of green tops than the control plots, which shows a decided advantage of the application of the three fertilizers used. The effect of the fertilizers was almost marvelous when the amount of N added was relatively higher than K and P in the combination. The effect was very prominent in the production of fiber. But liberal application of P-bearing and K-bearing fertilizers was detrimental to the plant.

In all cases the liberal application of N-bearing fertilizers with sufficient amount of P-bearing and K-bearing fertilizers gave the best results on the growth and height of the plant and yield of green tops and of clean fiber. This shows that roselle is greatly benefited by the application of N-bearing fertilizers.

—*Abstract by Eligio C. Ureta.*

WEATHER OBSERVATIONS

OBSERVATIONS ON MOUNT MAKILING TO BE DISCONTINUED

Weather observations have been made on Mount Makiling during the last ten years. Sufficient data have been secured to draw some conclusions in regard to the climate of the mountain. These observations have been made by members of the Department of Botany at the College of Agriculture. It is now the intention of the department to begin a study of the lake shore vegetation and the conditions governing its make-up. We are especially anxious to undertake this study since the lake shore regions are of great agricultural interest. The College is located near Laguna de Bay, thus making it admirably situated for such a study. As we have not sufficient observers or instruments available at the present time to continue the observations on Mount Makiling and, at the same time, begin our lake studies, we will discontinue the observations on Mount Makiling until further notice.

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[1] Abstract prepared as part of required theme work in English 4, College of Agriculture.

The publication of data for the three stations on Mount Makiling will be discontinued with the September, 1921, results in this issue of the *Philippine Agriculturist*. We are still fortunate in having the services of Mr. Estioko for taking readings on the various instruments.

FRANK P. MCWHORTER,
Of the Department of Plant Physiology.

The task of the doer is always trebled when the thinker has not been permitted to precede him.—*Grosvenor B. Clarkson.*

No man has a right to be idle. An idle man has no right to live in a community.—*Teodoro Yangco.*

The ultimate man will be the one whose private requirements coincide with the public ones.—*Herbert Spencer.*

From "Chips of Jade"

By Arthur Guiterman

A hero, fallen, strives to stand
Himself, and asks no helping hand.

Eight sailors; seven want to steer.
That junk won't come to port, I fear.

The starveling cat maintains the firm belief
That every well-fed cat must be a thief.

How small the Heavens are, the frog can tell;
He's seen them!—from the bottom of the well.

Fame is the dew on the jasmine stalk,
Fame is the scream of a passing hawk,
Fame is the foam of vessel's keel,
Fame is a dying thunder peal,
Fame is the scent on the mountain moss
Left when the musk deer bounds across.

Your arm is broken?—Do not grieve
Aloud, but hide it in your sleeve.

Oh, when the whale is floundering in the shoal,
How all the minnows laugh to see him roll!

In babbling, gorging food, or quenching drouth,
All mischief comes through opening the mouth.

Teach your son a trade before he's twenty,
whatsoe'er his powers.
Plant your fields with rice and beans a plenty—
not too many flowers.

COLLEGE AND ALUMNI NOTES

A RESOLUTION OF THE STUDENT BODY OF THE COLLEGE OF AGRICULTURE

Whereas, in the year of our Lord one thousand nine hundred and eighteen, world conditions were uncertain; and

Whereas, volunteering for the Philippine National Guard personnel was then the supreme test of the patriotic spirit of the Philippine citizenry; and

Whereas, the Student Body and Faculty of the College of Agriculture offered, as one, their services to the Philippine National Guard on the tenth day of October, 1918; and

Whereas, the spirit of loyalty of the men who then offered their services, at the sacrifice of their study, should always be looked on with special regard by future members of the College of Agriculture Student Body and Faculty, and should foster the spirit of loyalty among them; be it therefore

Resolved, by the Student Body of the College of Agriculture that the Board of Regents of the University of the Philippines be requested, through the Dean of the College of Agriculture, to set aside October 10, as Loyalty Day, a permanent College Day in the College of Agriculture calendar; and be it further

Resolved, that copies of this resolution be furnished the President of the University, the Board of Regents of the University, *The Varsity News*, and *The Philippine Agriculturist*.

ALEXANDER GORDON,
Chairman, Resolution Committee.

Dated at the College of Agriculture this tenth day of January, 1922.

RESOLUTIONS OF CONDOLENCE OF THE ALUMNI ASSOCIATION OF THE COLLEGE OF AGRICULTURE

Whereas, the early death of Dionisio Tuason, B. Agr. '17, of Orion, Bataan, means a loss to the College of Agriculture Alumni Association; and

Whereas, the death of said Dionisio Tuason means a loss of leadership for the fostering of modern agricultural science; and

Whereas, the pleasing personality, friendly character, and helpful quality of Dionisio Tuason always commanded our respect and sympathy; therefore be it

Resolved, that we express our deep sorrow for his untimely death, and be it further

Resolved, that a copy of this resolution be filed with the minutes of the Association and a copy be sent to the parents of the deceased, and be it further

Resolved, that *The Philippine Agriculturist*, *Philippine Agricultural Review*, *Progressive Agriculture* and *Philippine Farmer* be furnished a copy of these resolutions for publication.

JOSÉ P. ESQUERRA, *Chairman.*
PEDRO RODRIGO, *Member.*
FRANCISCO LAGO, *Member.*

Dated at the College of Agriculture, Los Baños, P. I., this 29th day of November, 1921.

At the special meeting of the Alumni Association of the College of Agriculture held in Los Baños on November 19, 1921, and at the suggestion of President Espino, it was decided to incorporate the Association. The Advisory Board, composed of the President, Vice-President, and the Treasurer of the society, has been authorized to prepare the articles of incorporation. These are to be submitted to the Government some time next month, and the Association is expected to be a non-stock corporation.

The Alumni Association of the College of Agriculture has decided to organize several athletic teams which will compete with similar organizations on the Campus or elsewhere. The teams which have just been formed, with a great deal of enthusiasm, are those pertaining to indoor baseball, basketball, baseball and tennis. These teams are managed by Dr. R. B. Espino, Mr. Florencio Soliven, Mr. Elias Panganiban and Dr. N. B. Mendiola respectively.

The indoor baseball team played its first game with a team of the faculty of the College of Veterinary Science. The Veterinary team was badly defeated. The second game was with the College Seniors and was played immediately after the game with the Veterinarians.

The usual annual review of College athletics, heretofore published in this department, will appear for 1921-1922 in *The Plow*, the senior annual of the students of the College of Agriculture.

Judging from a letter dated December 14, received by Prof. Emma S. Yule, from Leonardo Salinas, '21, he finds his job in British North Borneo no sinecure. The letter shows also that Mr. Salinas is a cheerful hustler; no whines or kicks. He writes about his work thus:

I assume that you would be glad to know something about Borneo and my work here. British North Borneo is one of the states in Borneo, probably as large as Luzon and under the protection of the British Government. Sandakan is seemingly the capital for most of the Departments of the State are here, although Jesselton is the capital. The whole state is owned by a company, "The British North Borneo Co." Then the state is loaned to many small companies for the cultivation of different crops on a big scale. Because of impracticability for these companies to run experiments on some agricultural problems the Government proposes to support an Experiment Station for solving any problems that from time to time these companies may encounter. It has been decided that the station should be in or near Sandakan and near good transportation facilities. I was called upon to take charge of the said station and my work is under the supervision of the Conservator of Forests of the Forestry Department, Sandakan.

I began the work last September. I was given 550 acres. This whole area is covered with jungle where many elephants live. Until the president of the company, who is in London, approves having the whole area cleared my supervisor advised me to clear only 100 acres. As soon as we receive orders from London and bigger fund for this work then we shall take steps on it at once. By about the middle of October I had surveyed this jungle, cleared 27 acres, had built my house out of nipa and "cajangs" size 15 feet by 35 feet with 2 rooms, floored with boards and a separate hut for kitchen. I have also a big "congche," a big house for my coolies and a nursery house 20 feet by 35 feet.

My place is entirely isolated. It is eight miles from Sandakan by the Sandakan-Laboc road which is being constructed. During my first three weeks in the jungle I felt very lonely, for I mingled only with the coolies and I could not speak with them because they speak Malay. After

two months here, however, I enjoy jungle life beautifully and my friends here were surprised because I can speak with them in Malay as fluen tly as my own dialect. Malay language is somewhat a combination of the different dialects of the Philippines. I know three Philippine dialects so I did not have much difficulty to learn Malay. Do you want a big elephant as my Christmas present to you? They roam near my house at night. They are very noisy so that I can easily tell when they are coming. I am very much afraid of them but the Malayan coolies are not. They do no harm unless they are troubled. There are many wild pigs, big ones, also deer. The Malay people do not like to kill pigs because they are Mahommedans. I have seen many kinds of animals here that I have not seen in the Philippines.

My work is not only in the Experiment Garden but from time to time I am called upon to go to some districts or towns for reconnaissance work. Also as a Landscape Gardener in Sandakan. But my permanent station is here in the Experiment Garden. Whenever I go out I collect per diem in addition to my pay. Since October 18 I was out of my station and came back here December 12. When I came back I brought some coolies with me. I burned about two acres of my cleared lot and am now planting teak trees and lumbang. The lumber of the former has a good market price for ship and "banca" construction while the latter produces the fruits from which the lumbang oil is extracted. I have already planted five varieties of African oil palm. This palm produces an edible oil, good substitute for lard and there is an increasing demand for this oil in Europe. We want to run an experiment to secure data on the stand of this palm here. If it thrives well then we shall recommend its cultivation on a large scale to the small companies of British North Borneo.

Make yourself necessary to the world, and mankind will give you bread, and if not store of it, yet such as shall not take away your property in all men's possessions, in all men's affections, in art, in nature, and in hope.—*Emerson.*

Economic organization is the word; political parties are as prehistoric as the mastodon, if they only knew it.—*Canfield.*

WEATHER OBSERVATIONS, JUNE, 1921.

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
June	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles.*	*miles.*	
1	4.1		30.2	23.2	26.7		57.2		¾ cloudy
2	1.0		30.0	23.6	26.8		55.7		cloudy
3	43.4		28.2	22.6	25.4		30.1		cloudy
4	4.9	108.6	30.0	21.6	25.8	26.8	57.7	370.3	½ cloudy
5	1.5		29.5	21.8	25.6		49.8		cloudy
6	T		29.0	23.6	26.3		54.0		cloudy
7	5.2		30.1	22.6	26.4		62.0		¾ cloudy
8	1.2		30.2	23.4	26.8		42.7		cloudy
9	8.0		29.0	22.6	25.8		47.1		cloudy
10	2.6		30.2	23.6	26.9		50.7		¾ cloudy
11	O	18.5	30.8	23.6	27.2	26.4	72.7	379.0	½ cloudy
12	O		31.0	23.3	27.1		27.8		¾ cloudy
13	9.7		31.2	23.8	27.5		45.1		¾ cloudy
14	20.5		27.8	23.2	25.5		32.9		cloudy
15	8.9		28.0	23.6	25.8		83.3		cloudy
16	.6		27.0	25.1	26.1		166.2		cloudy
17	.7		28.6	23.4	26.0		74.9		cloudy
18	.4	40.8	30.5	22.6	26.5	26.3	39.1	469.3	½ cloudy
19	.0		31.0	23.2	27.1		53.3		¾ cloudy
20	.0		30.2	22.8	26.5		34.8		¾ cloudy
21	.0		30.0	23.6	26.5		53.4		cloudy
22	2.7		31.0	23.6	27.3		75.3		½ cloudy
23	2.5		27.8	24.6	27.2		61.5		¾ cloudy
24	24.2		27.5	23.8	25.9		41.6		cloudy
25	.2	29.6	29.2	22.6	25.9	22.6	49.3	369.2	½ cloudy
26	O		31.6	22.9	27.2		60.8		½ cloudy
27	O		30.9	23.1	27.0		64.0		½ cloudy
28	6.2		30.0	23.1	26.6		52.3		½ cloudy
29	O		30.6	23.6	27.1		70.3		½ cloudy
30	O		31.8	24.6	28.2		100.3		½ cloudy
Monthly		147.5	29.8	23.3	26.6	58.9	1765.9		

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
		mm.	*°C.*	*°C.*	*°C.*
College Coffee Plantation.....	May 30 to June 5	25.5	34.2	20.6	27.4
	June 6 to June 12	33.7	34.0	20.2	27.1
	June 13 to June 19	41.2	33.8	20.0	26.9
	June 20 to June 26	31.2	33.5	20.0	26.7
	June 27 to July 3	21.6	33.4	19.8	26.6
450 Meters Elevation.....	May 30 to June 5	35.6			
	June 6 to June 12	32.4			
	June 13 to June 19	35.6			
	June 20 to June 26	34.1			
	June 27 to July 3	8.1			
Summit.....	May 30 to June 5	14.2	—	—	—
	June 6 to June 12	39.7	23.1	18.7	20.9
	June 13 to June 19	52.6	22.1	18.8	20.4
	June 20 to June 26	42.5	22.8	18.5	20.6
	June 27 to July 3	12.4	22.7	18.8	19.8

WEATHER OBSERVATIONS, JULY, 1921

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
July	*mm.*	*mm.*	*°C*	*°C*	*°C*	*°C*	*miles.*	*miles.*	
1	1.5		30.9	23.8	27.3		50.2		¾ cloudy
2	1.8	9.5	29.5	22.6	26.1	27.1	50.8	448.1	¾ cloudy
3	T		28.3	22.9	25.6		46.5		cloudy
4	278.7		24.0	23.0	23.5		252.6		cloudy
5	34.4		28.6	23.1	25.8		209.7		cloudy
6	O		29.2	23.1	26.2		92.6		cloudy
7	1.0		29.0	24.4	26.7		72.2		cloudy
8	8.7		29.5	23.6	26.5		59.5		cloudy
9	4.7	327.7	28.0	23.5	25.8	25.7	48.2	781.3	cloudy
10	10.5		30.3	23.6	26.9		49.6		cloudy
11	O		30.0	23.6	26.8		56.2		½ cloudy
12	O		30.2	24.1	27.2		50.2		½ cloudy
13	O		31.0	23.6	27.3		77.6		½ cloudy
14	O		30.6	23.4	27.0		60.4		½ cloudy
15	O		31.8	23.0	27.4		52.9		½ cloudy
16	4.7	15.2	30.5	23.6	27.0	27.0	69.6	416.5	¾ cloudy
17	31.2		29.4	22.1	25.8		52.0		¾ cloudy
18	6.5		30.0	23.8	26.9		49.2		¾ cloudy
19	29.5		28.5	23.1	25.8		53.7		cloudy
20	.3		30.0	23.1	26.5		67.8		cloudy
21	.4		30.0	24.8	27.4		101.9		cloudy
22	4.6		28.5	25.6	27.1		175.4		cloudy
23	20.4	92.9	28.0	24.4	26.2	26.5	126.2	626.2	cloudy
24	3.2		29.0	23.6	26.3		108.6		cloudy
25	1.5		31.0	23.6	27.3		62.1		cloudy
26	T		29.0	23.8	26.4		49.7		¾ cloudy
27	O		30.8	23.0	26.9		94.4		¾ cloudy
28	O		31.5	22.9	27.2		125.3		½ cloudy
29	O		32.0	24.1	28.0		63.9		½ cloudy
30	O	4.7	31.0	24.1	27.6	27.1	99.6	603.6	½ cloudy
31	O		31.5	23.6	27.5		60.7		½ cloudy
Monthly		443.8	29.7	23.6	26.6		83.5	2589.3	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	July 4 to July 10	315.6	33.0	20.0	26.5
	July 11 to July 17	60.4	33.5	19.5	26.5
	July 18 to July 24	88.4	33.4	19.4	26.4
	July 25 to July 31	8.7	33.7	19.5	26.6
450 Meters Elevation	July 4 to July 10	330.7			
	July 11 to July 17	58.2			
	July 18 to July 24	90.7			
	July 25 to July 31	5.2			
Summit	July 4 to July 10	277.6	20.8	19.0	19.9
	July 11 to July 17	20.2	21.6	18.6	20.1
	July 18 to July 24	87.5	21.3	18.8	20.0
	July 25 to July 31	7.5	22.3	19.2	20.7

WEATHER OBSERVATIONS, AUGUST, 1921

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.	% Humidity.	Atmometer Readings in cc			
											Evaporation.		Insolation.	
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.			Daily.	Weekly.	Daily.	Weekly.
Aug.	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles.*	*miles.*						
1	8.3		31.5	23.6	27.0		19.5		cloudy		13.7		9.0	
2	0		30.0	23.6	26.9		51.8		cloudy		11.2		10.6	
3	0		33.3	24.1	28.7		41.0		cloudy		14.7		9.1	
4	3.0		29.2	24.0	26.6		50.8		¾ cloudy		14.6		9.7	
5	0		28.0	24.6	26.3		121.2		½ cloudy		26.4		7.9	
6	56.4	67.7	28.5	26.1	27.3	27.2	161.9	506.9	cloudy		24.1	104.7	5.2	51.5
7	33.3		27.0	23.0	25.0		61.8		cloudy		2.8		1.5	
8	T		30.0	22.6	26.3		48.1		¼ cloudy		13.5		10.8	
9	1.5		30.0	23.1	26.5		41.8		¾ cloudy		11.9		9.9	
10	2.7		30.0	23.1	26.5		45.0		¾ cloudy		9.4		11.4	
11	.7		28.7	23.6	26.1		48.9		cloudy		15.6		10.2	
12	3.2		29.0	23.6	26.3		84.5		¾ cloudy		16.7		10.7	
13	20.2	61.6	28.8	24.1	26.4	26.1	70.8	400.9	cloudy	88.5	11.6	81.5	6.9	61.4
14	9.5		28.5	24.1	26.3		242.6		¾ cloudy	82.8	22.8		6.5	
15	59.2		27.0	23.4	25.2		78.3		cloudy	92.8	6.9		.9	
16	86.8		27.0	22.6	24.8		125.7		cloudy	96.0	5.9		2.9	
17	.4		29.5	23.6	26.5		111.8		cloudy	68.5	26.0		9.6	
18	0		30.7	23.6	27.7		94.8		¾ cloudy	79.2	31.5		12.9	
19	0		29.4	24.6	27.0		93.5		cloudy	74.5	28.6		9.8	
20	0	155.9	30.0	25.6	27.8	26.5	101.3	848.0	cloudy	80.5	31.7	153.4	17.3	59.9
21	0		30.4	25.0	27.7		84.5		½ cloudy	79.5	36.5		15.4	
22	.8		30.0	25.1	27.5		99.7		cloudy	86.8	28.2		10.3	
23	2.8		29.8	24.4	27.1		61.0		cloudy	88.2	18.8		12.1	
24	0		28.5	23.6	26.0		37.7		cloudy	86.3	13.0		7.8	
25	T		30.0	22.1	26.1		50.9		½ cloudy	84.8	19.4		14.9	
26	0		30.0	23.2	26.6		51.2		¼ cloudy	85.8	20.7		11.0	
27	T	3.6	31.0	24.1	27.5	26.9	39.8	424.8	¾ cloudy	84.5	17.7	154.3	9.8	81.3
28	36.6		29.0	22.6	25.8		49.4		¾ cloudy	90.3	8.7		6.8	
29	4.6		28.2	23.1	25.7		40.9		¾ cloudy	90.0	16.4		2.7	
30	1.7		26.7	22.9	24.8		37.1		¾ cloudy	88.0	8.6		8.2	
31	12.5		26.0	22.9	24.4		85.2		cloudy	89.8	7.4		3.9	
Monthly		344.2	29.2	23.7	26.4	26.3	75.2	2332.5		85.1	17.2	535.0	8.9	275.7

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	Aug. 1 to Aug. 7	170.9	34.0	20.5	27.2
	Aug. 8 to Aug. 14	56.8	32.0	21.5	26.8
	Aug. 15 to Aug. 21	195.4	31.5	20.5	26.0
	Aug. 22 to Aug. 28	67.4	32.4	20.3	26.3
450 Meters Elevation	Aug. 1 to Aug. 7	172.6			
	Aug. 8 to Aug. 14	59.7			
	Aug. 15 to Aug. 21	186.7			
	Aug. 22 to Aug. 28	68.9			
Summit	Aug. 1 to Aug. 7	139.1			
	Aug. 8 to Aug. 14	62.7	21.0	18.3	19.7
	Aug. 15 to Aug. 21	170.6	20.0	18.6	19.3
	Aug. 22 to Aug. 28	61.7	20.9	18.3	19.6

WEATHER OBSERVATIONS, SEPTEMBER, 1921

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		% Humidity.	Cloudiness.	Atmometer Readings in cc.			
											Evaporation		Insolation.	
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.			Daily.	Weekly.	Daily.	Weekly.
Sept.	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles.*	*miles.*						
1	6.8		28.0	22.8	25.4		68.1		97.0	cloudy	9.4		9.1	
2	28.6		27.8	24.6	26.2		102.4		91.5	cloudy	8.9		8.2	
3	T	90.8	28.7	22.6	25.7	25.4	68.0	471.1	89.5	¾ cloudy	12.5	71.9	7.5	46.4
4	T		28.5	22.8	25.6		72.5		88.5	cloudy	13.2		7.9	
5	2.6		27.6	22.8	25.2		41.2		84.7	½ cloudy	8.6		6.9	
6	.9		28.0	23.2	25.6		36.4		93.5	cloudy	5.6		5.8	
7	O		28.8	22.6	25.7		38.5		90.5	cloudy	9.7		8.3	
8	16.2		27.8	22.6	25.2		44.2		91.7	¾ cloudy	7.3		5.9	
9	.5		29.2	22.6	25.9		55.1		85.5	½ cloudy	16.7		9.1	
10	O	20.2	29.2	23.8	26.5	25.7	45.7	333.6	83.5	½ cloudy	16.2	67.3	10.3	54.2
11	27.0		27.2	22.6	24.9		35.9		86.2	cloudy	6.2		5.0	
12	.5		28.8	23.3	26.0		47.8		86.2	¾ cloudy	15.5		4.5	
13	.2		29.0	24.6	26.8		90.7		82.5	cloudy	23.8		8.6	
14	1.0		29.0	23.6	26.3		32.6		90.7	¾ cloudy	8.8		6.6	
15	8.8		29.0	23.6	26.3		40.7		88.7	cloudy	8.6		7.8	
16	1.5		30.8	23.1	26.5		83.7		80.2	½ cloudy	21.9		9.4	
17	5.3	44.3	29.0	24.1	26.6	26.2	53.3	384.7	85.5	¾ cloudy	14.3	99.1	8.1	50.0
18	3.6		28.0	23.1	25.5		51.5		84.5	cloudy	11.3		6.7	
19	1.8		30.0	22.4	26.2		51.3		91.2	¾ cloudy	13.6		10.6	
20	29.9		29.2	22.8	26.0		56.7		88.7	½ cloudy	13.5		8.5	
21	30.7		28.0	23.6	25.8		36.1		80.2	¾ cloudy	9.7		6.8	
22	O		28.0	23.6	25.8		40.1			cloudy	12.0		7.7	
23	30.4		28.0	23.8	25.9		39.9			cloudy	9.1		3.9	49.0
24	19.4	115.8	28.2	23.1	25.7	25.8	43.3	318.9		cloudy	10.1	79.3	4.8	
25	O		29.0	23.1	26.0		40.9			¾ cloudy	13.0		5.0	
26	.6		28.0	23.1	25.6		51.4			¾ cloudy	11.1		5.2	
27	39.1		26.2	21.6	23.9		56.2			cloudy	5.4		5.2	
28	O		28.2	23.4	26.0		40.9			¾ cloudy	10.1		8.3	
29	O		30.0	23.1	26.5		99.9			¾ cloudy	21.2		12.8	
30	55.5	95.2	26.2	23.0	24.6	25.4	48.1	319.5		cloudy	6.0	66.8	2.0	38.5
Monthly		364.9	28.4	23.2	25.8	25.8	93.2	1595.2			11.4	343.3	7.2	216.5